NUREG-75/087

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 12.3 RADIATION PROTECTION DESIGN FEATURES

REVIEW RESPONSIBILITIES

Primary - Radiological Assessment Branch (RAB)

Secondary - None

I. AREAS OF REVIEW

The following areas of the applicant's safety analysis report (SAR) relating to radiation protection design features are reviewed:

1. FACILITY DESIGN FEATURES
   a. In the preliminary safety analysis report (PSAR), the description of equipment and facility design features used for assuring that occupational radiation exposures (ORE) will be as low as is reasonably achievable (ALARA).
   b. The radiation zone designations, including zone boundaries for both normal operational and refueling conditions (PSAR and update in the final safety analysis report, FSAR).
   c. The illustrative examples of facility design features of the equipment, components, and systems lised in Sections 12.1.3 and 12.3.1 of "Standard Format and Content...." (Ref. 1) including the scaled layout and arrangement drawings of the facility showing all source locations and the other design details requested in Section 12.3.1 of the "Standard Format...." (PSAR and update in FSAR). Shield wall thicknesses for all shielded spaces should be specified on the drawings or provided in separate tables.
   d. The description of facilities and equipment for handling and use of sealed and unsealed special nuclear, source, and byproduct materials (PSAR and update in FSAR).
   e. Information describing implementation of Regulatory Guide 8.8 guidelines on facility and equipment design and layout. Information describing alternatives, if such are proposed (PSAR and update in FSAR).

2. SHIELDING
   a. The shielding to be provided for each of the radiation sources identified in SAR Chapter 11 and Section 12.2, including the design criteria for penetrations and the shield material used (PSAR and update in FSAR). (Note item I.1.c above)

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to Revision 2 of the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

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b. The description of the methods by which the shield parameters were determined, including pertinent codes, assumptions, and techniques used or to be used in the calculations (PSAR and update in FSAR).

c. The description of any special protective features that use shielding, geometric arrangement, or remote handling to assure that ORE will be ALARA (PSAR and update in FSAR).

d. Information describing implementation of Regulatory Guides 1.69 and 8.8 (regarding special protective features). Information describing alternatives, if such are proposed (PSAR and update in FSAR).

3. VENTILATION

a. The description of the personnel protection features incorporated in the ventilation system design as called for in Section 12.3.3 of "Standard Format and Content..." (PSAR and update in FSAR).

b. Illustrative example of the air cleaning system design (PSAR and update in FSAR).

c. Information describing any application of Regulatory Guide 1.52 (particularly Section C.4 & 5) and Regulatory Guide 8.8. Information describing alternatives, if such are proposed (PSAR and update in FSAR).

4. AREA RADIATION AND AIRBORNE RADIOACTIVITY MONITORING INSTRUMENTATION

a. The description of the fixed area radiation and continuous airborne radioactivity monitoring instrumentation, including in the PSAR the criteria for placement and in the FSAR additional details as called for in Section 12.3.4, "Standard Format and Content....," for normal operation, anticipated operational occurrences, and accident conditions.

b. The criteria and method for obtaining representative in-plant airborne radioactivity concentrations (PSAR and update in FSAR).

c. Information describing the implementation of Regulatory Guides 1.21, 8.2, 8.8 and ANSI N13.1-1969. Information describing alternatives, if such are proposed (PSAR and update in FSAR).

II. ACCEPTANCE CRITERIA

The descriptive information in the SAR is considered to be sufficient if it meets the minimum information needs set forth in Section 12.3 of the "Standard Format and Contents of Safety Analysis Reports for Nuclear Power Plants," Revision 2. Specific acceptance criteria for these areas of review are as follows:

1. FACILITY DESIGN FEATURES

Acceptability of the facility design features will be based on evidence that the applicant has applied the guidance in Regulatory Guide 8.8 or that alternatives have been proposed. This includes evidence that major exposure accumulating functions (maintenance, refueling, radioactive material handling, processing, etc., in-service inspection and calibration) have been considered in plant design and that potential radiation exposure from these activities will be kept ALARA by radiation protection features incorporated in the design, including ease of accessibility to work and inspection and sampling areas, the ability to reduce source intensity, design measures to reduce the production, distribution, and retention of activated corrosion products, the ability to reduce time required in radiation fields, provision for portable shielding and remote handling tools, etc. Access control will be judged for acceptability in accordance with the requirements of 10 CFR § 20.203.

The areas inside the plant structures, as well as the general plant yard, must be identified by showing radiation areas with acceptable maximum design dose rates and zones. Maximum zone dose rate should be defined for each zone, as well as anticipated occupancy and access control. Acceptance criteria are as follows: The areas that have to be occupied on a predictable basis (number of people and stay or transit times) during normal operations and anticipated operational occurrences (including refueling; purging; fuel handling and storage; radioactive material handling; processing, use, storage and disposal; normal maintenance; routine operational surveillance; inservice inspection; and calibration) should be zoned such that this occupancy results in an annual dose to each of the involved individuals that is below the limits of 10 CFR Part 20 and is as low as is reasonably achievable. Based on current operating experience and on predictions made for new plant designs, it is expected that the plant shielding can be designed, the plant can be zoned and sufficient radiation protection design features can be incorporated such that these individuals would receive a small fraction of the 10 CFR Part 20 limit. Whether radiation protection design and zoning is acceptable will be based partly on the actual numbers for average annual radiation exposure to these individuals, determined in the dose assessment required in Section 12.4.

2. SHIELDING

The shielding design is evaluated as to the assumptions used to calculate shield thickness, the calculational method used, and the parameters chosen. There are a number of acceptable shielding calculational codes available for use that are effective for determining the necessary shield thickness for gamma ray sources and for combination neutron-gamma sources. Most of the codes used by shield designers have been entered into the code description file of the Radiation Shielding Infomation Center at Oak Ridge National Laboratory, which means they have been tested and authenticated for operation but not for reliability and accuracy. RAB has three codes in-house for use in shielding calculations. These are SDC, a kernal integration shield design code; G^3, a general purpose gamma ray scattering program; and MORSE, a general purpose Monte Carlo multigroup neutron and gamma ray transport code. SDC can calculate gamma ray shielding requirements, handling 13 source geometries (including point, line, disk, plane, slab, and sphere) and with cross sections and materials compositions for 17 materials. As many as 12 gamma ray energy groups, covering the range from 0.1 to 10 MeV, may be used to describe the gamma ray spectrum. The staff will use these codes, as necessary, to calculate dose rates for given shield designs and source strengths, as a confirmation of the applicant's method.

The applicant's shielding design is acceptable if the methods are comparable to commonly acceptable shielding calculations and assumptions regarding source terms, cross sections, shield and source geometries, and transport methods are realistic. Acceptable shielding codes include but are not limited to ANISN, DOT, MORSE, SAM-CE, O5R, O6R, G^3, SDC, and many others. This listing does not imply that all these codes are equivalent, since some are much more sophisticated than others. The staff believes it is advantageous to use a good calculational procedure, since an effective shield design is essential to meeting the criteria that occupational radiation exposures will be as low as is reasonably achievable.

Two documents provide additional guidance for acceptability of the shielding design. One is "Reactor Shielding for Nuclear Engineers," Edited by N. M. Schaeffer, published by AEC-OIS, 1973." The second is the Stone & Webster Engineering Corporation topical report RP-8 entitled "Radiation Shielding Design and Analysis Approach for Light Water Reactor Power Plants." These documents provide useful guidance regarding radiation shielding design. Some limitations are noted for RP-8, in that the labyrinth entrance ways may not provide dose rates at the outside entrance consistent with area radiation zoning.

In addition, Regulatory Guide 1.69 provides guidance on the fabrication and installation of concrete radiation shields for nuclear power plants. Acceptability of the shield construction will be based on an indication that the guidance of this document has been implemented in the facility construction, or that acceptable alternatives have been proposed. Regulatory Guide 8.8 provides additional acceptance criteria regarding shielding and isolation in radiation protection design.

3. VENTILATION

The ventilation system will be acceptable for radiation protection purposes if the criteria and bases for ventilation rates within the areas covered in SAR Section 12.2.2 will assure that air will flow from areas of low potential airborne radioactivity to areas of higher airborne radioactivity and then to filters or vents, and that the concentrations of radioactive material in areas normally occupied can be maintained in accordance with the requirements of 10 CFR Part 20. The system shall have adequate capability to reduce concentrations of airborne radioactivity in areas not normally occupied where maintenance or in-service inspection has to be performed, to levels in accordance with the requirements of 10 CFR § 20.103. The system shall be designed so that filters containing radioactivity can be easily maintained and will not create an additional radiation hazard to personnel in normally occupied areas. Acceptability of the ventilation system, relative to radioactive gases and particulates will also be based on evidence that the applicant has applied the guidance of Regulatory Guide 8.8 or that alternatives have been prepared.

Regulatory Guide 1.52, particularly Sections C.4 and 5, provides guidance that can be used in this review, although the guide is written with regard to mitigating accidents involving airborne radioactivity. Good practice in that regard is applicable to normal operation as well, since release of radioactivity in normal operational occurrences is usually different only in quantity from some of the accident cases.

4. AREA RADIATION AND AIRBORNE RADIOACTIVITY MONITORING INSTRUMENTATION

The area radiation monitoring instruments will be acceptable if they meet the following criteria:

a. The detectors are located in areas and normal access corridors used and occupied without restricted access which may have a potential for radiation fields in excess of the radiation zone designation given in Section 12.3.1.

b. The detectors are sensitive to dose rates that include the design maximum dose rate of the radiation zone in which they are located as well as the maximum dose rate for anticipated operational occurrences.

c. Essential instruments are provided with "auxiliary" or emergency power in the event of a power failure or postulated accidents. Specific criteria are being developed.

d. The detectors are calibrated routinely and after any maintenance work is performed on the detector. Specific criteria are being developed.

e. Each location has a local audible alarm and variable alarm set points. Monitors located in high noise areas should also have visual alarms.

f. There is readout and annunciation in the control room.

The continuous airborne radioactivity monitoring system will be acceptable if it meets the following criteria in addition to the above:

a. Air is sampled at normally occupied locations where airborne radioactivity is most likely to exist, such as solid waste handling areas, spent fuel pools, reactor operating floors, and BWR turbine buildings, and is detected based on sensitivity of the detection system. Monitoring air being exhausted from locations within the facility is also acceptable during normal operation, provided the monitoring system is capable of detecting one Mpc-hour (particulate or gaseous radioactivity) in any compartment which had a possibility of containing airborne radioactivity and which may be occupied by personnel.

b. Representative air concentrations are measured at the detectors, which are located as close to the sampler intakes as possible.

c. Ventilation monitors are upstream of HEPA filters.

Regulatory Guide 1.21, "Measuring and Reporting of Effluents from Nuclear Power Plants," provides useful guidance that is applicable to the acceptability of airborne radioactivity monitoring in-plant. Regulatory Guide 8.2, includes guidance on surveys to evaluate radiation hazard. American National Standard ANSI N13.1-1969 provides detailed guidance on sampling airborne radioactive materials in nuclear facilities and may be used for acceptance criteria on the actual sampling process and certain techniques involved. Regulatory Guide 8.8 provides guidance on monitoring systems.

III. REVIEW PROCEDURES

The information radiation protection design features furnished in the SAR, including referenced parts of Chapters 9 and 11, is reviewed for completeness in accordance with the "Standard Format and Contents of Safety Analysis Reports for Nuclear Power Plants," Revision 2. The reviewer evaluates the SAR text and the scaled layout drawings of the facility, concentrating on the sources, shielding, and layouts for the auxiliary building, including the radwaste systems, decontamination facilities, office and access control areas, laundry, lockers and shower rooms, and laboratory facilities; the fuel handling facilities, including the spent fuel pool and related equipment; and the BWR turbine building, including location of steam lines, reheaters, and moisture separators. For the PSAR this review is particularly concerned with preliminary design features which appear to be contradictory to assuring that ORE will be ALARA. In this review, radiation protection design features are evaluated using the guidelines of Regulatory Guide 8.8. The access control plans are reviewed both to determine conformance with 10 CFR Part 20 and to determine whether they will control access properly in limited access areas and in restricted access areas (high radiation areas). The reviewer examines locations of critical controls, valve operating stations, pumps, sample collection stations, inservice inspection locations, radiation monitors, control panels, major pipes carrying radioactivity, filters for radioactive liquids and gases, and unshielded low level radioactive material storage or processing tanks. He also reviews SAR Chapters 9 and 11 to cover specific details of the fuel handling and storage systems, ventilation systems, and radwaste systems as they relate to radiation protection design. Chapter 9 will provide the major description of the mechanical features of ventilation systems with regard to the venting airborne radioactivity from the plant. Chapter 9 will also cover major features of the spent fuel pool design, the fuel handling system design and the spent fuel pool cleanup system. Chapter 11 may cover some of the design details of gaseous, liquid and solid radwaste systems that relate to radiation protection. The reviewer evaluates all aspects of the initial design plans under his areas of review, particularly to identify new arrangements, improved designs, unusual shield thicknesses, a new or modified shield thickness calculational procedure, unusual assumptions in the calculation, placement of radiation monitors, etc.

RAB evaluates the adequacy of the applicant's shielding design on the basis of acceptable radiation shielding codes. RAB makes a verifying check calculation with SDC, G^3, or MORSE, whichever is specifically applicable to the situation.

For the FSAR the reviewer considers any changes in the design that might necessitate changes in operating procedures to accommodate a changed radiation zone or a different location of equipment.

The reviewer determines whether the applicant has followed the guidance of the referenced Regulatory Guides and industry standards, both by comparison of the applicant's methods with the information in the guides and by the applicant's reference to any such guides or to alternatives that have been proposed. The reviewer evaluates whether the alternatives are equivalent to or improvements on the methods cited in the referenced Regulatory Guides. Alternatives that are neither of these are likely to be disapproved.

Based on the review, RAB may request additional information or request the applicant to reevaluate the radiation protection design features to meet the acceptance criteria of Section II.

IV. EVALUATION FINDINGS

The staff's review should verify that adequate and sufficient information is contained in the SAR and amendments to arrive at conclusions of the following type, which are to be included in the staff's Safety Evaluation report. The report will include a summary of the applicant's coverage, the staff's basis for review and acceptance criteria, and the findings of the review. The following is a brief representation of the evaluation findings:

"12.3 Radiation Protection Design Features

"This section of the applicant's SAR has been reviewed to determine that the radiation protection design features of the plant have been designed and provided in a manner that will assure that ORE will be ALARA. The scope of review covers the facility design features, the shielding, the ventilation systems, and the radiation monitoring instrumentation, as they relate to the plant radiation protection design.

"Basis for acceptance in the review has been conformance with established guidelines and criteria. The evaluation of the radiation protection design features provides reasonable assurance that it will be possible to operate the facility with ORE that are ALARA.

"The staff concludes that the protective features provided in the design of ____________ nuclear plant conform to the Commission's Regulations, and to applicable Regulatory Guides, and industry standards, and are acceptable."

V. REFERENCES

1. Regulatory Guide 1.70, "Standard Format and Contents of Safety Analysis Reports for Nuclear Power Plants," Revision 2.

2. Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Radiation Exposure As Low As Practicable."

3. ANSI N13.1-1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities," American National Standards Institute (1969).

4. Regulatory Guide 1.69, "Concrete Radiation Shields for Nuclear Power Plants."

5. Regulatory Guide 8.2, "Guide for Administrative Practices in Radiation Monitoring."

6. "Reactor Shielding for Nuclear Engineers," N. M. Schaeffer, Editor; published by USAEC-OIS, 1973.

7. Regulatory Guide 1.52, "Design, Test, and Maintenance Criteria for Atmosphere Cleanup System Air Filtration and Absorption Units of Light Water Cooled Nuclear Power Plants."

8. Regulatory Guide 1.21, "Measuring and Reporting of Effluents from Nuclear Power Plants."

9. 10 CFR Part 20, "Standards for Protection Against Radiation."

10. Stone and Webster Topical Report, "Radiation Shielding Design and Analysis Approach for Light Water Reactor Power Plants," RP-8, 1974.

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